Air-sea interaction and precipitation over oceans: acoustic rain measurements and application of RainFARM downscaling technique to IMERG

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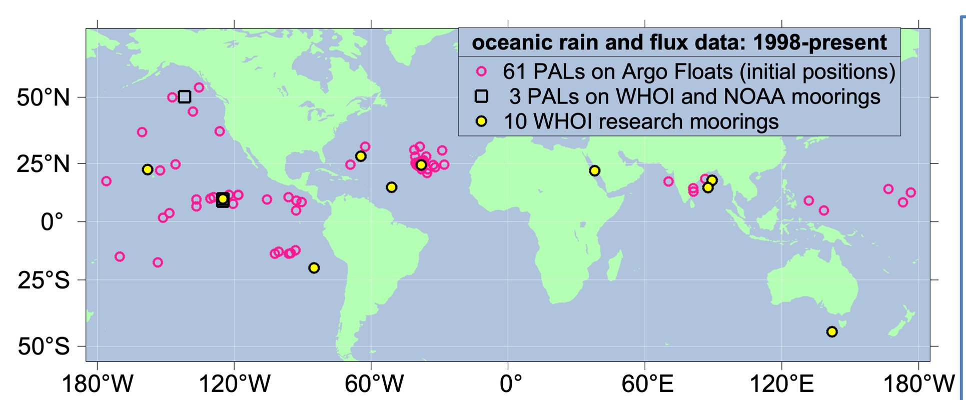
Motivation:

Higher resolution rain information must be *extracted (*farmed*)* from IMERG to use remotely-sensed rain data to study air-sea interaction:

- ocean freshening, ocean stability and heat content, surface fluxes

A **downscaled version of IMERG** and **oceanic acoustic rain measurements** are needed for studies of air-sea interaction and oceanography because fluxes are forced by **instantaneous rain rate**

- IMERG has effective resolution ~ 15-30 km, and rain amounts represent a 30-90 minute mean rate
- *Ocean Validation "OV"* is needed for 75% of Earth not covered by GV
- Error characterization is also needed for satellite rain products; downscaling iterations can help
- These downscaled products are also relevant for convective parameterizations and studies of high-impact weather, weather and climate monitoring, and atmospheric dynamics



The PAL "Ocean Validation (OV)" dataset of rain rate and wind will be produced and then provided to PMM science team

Yang et al. 2015 TOS, Riser et al. 2019 TOS

Objectives:

1. Test RainFARM downscaling method on IMERG; produce in-situ oceanic acoustic rain and wind datasets from PALs (*this poster*)
2. Compare in-situ acoustic rain dataset to original vs. downscaled IMERG
3. Use in-situ rain, downscaled IMERG, and original IMERG to estimate rain's impact on ocean

Objective 1a: produce rain and wind dataset from global array of oceanic acoustic sensors

In-Situ Data and Methods:

PAL = Passive Acoustic Listener developed at Univ. Washington's Applied Physics Lab
most recent: Yang et al. 2015 *TOS*, Riser et al. 2019 *TOS*

2 types of PALs: 65 in total available for satellite and in-situ rain studies

- PAL on Argo drifter
- PAL in pressure housing on mooring line

PAL method from native recording to rain product: time series of ambient sound -> frequency spectrum 1-50 kHz -> classification algorithm to determine noise source -> isolate sound pressure level (SPL) from wind and rain sources -> time series of wind speed and rain rate (1 min, ~1-5 km)

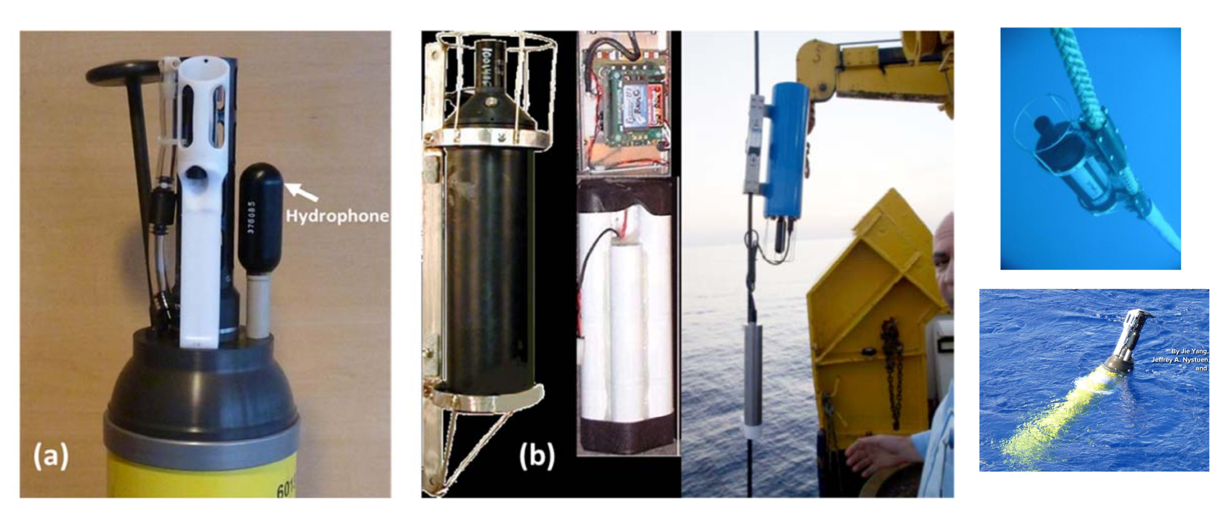
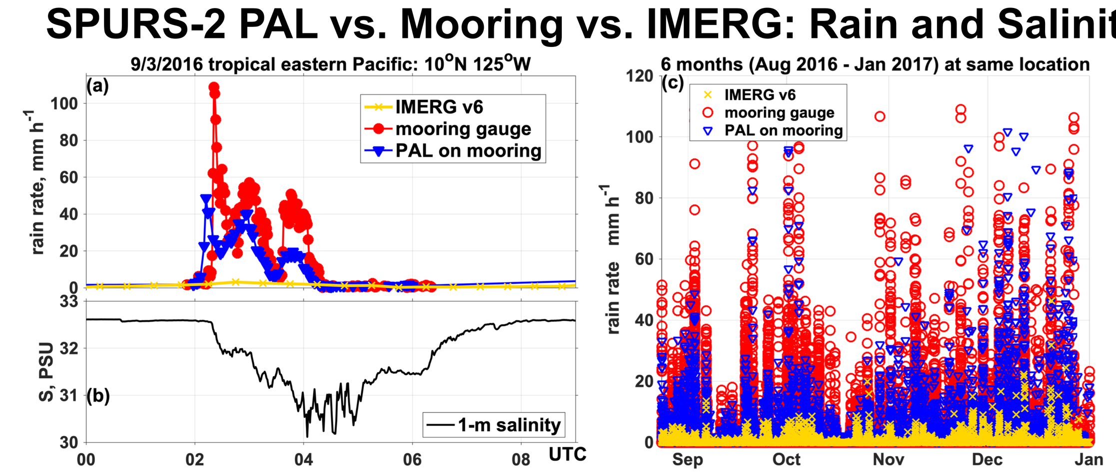
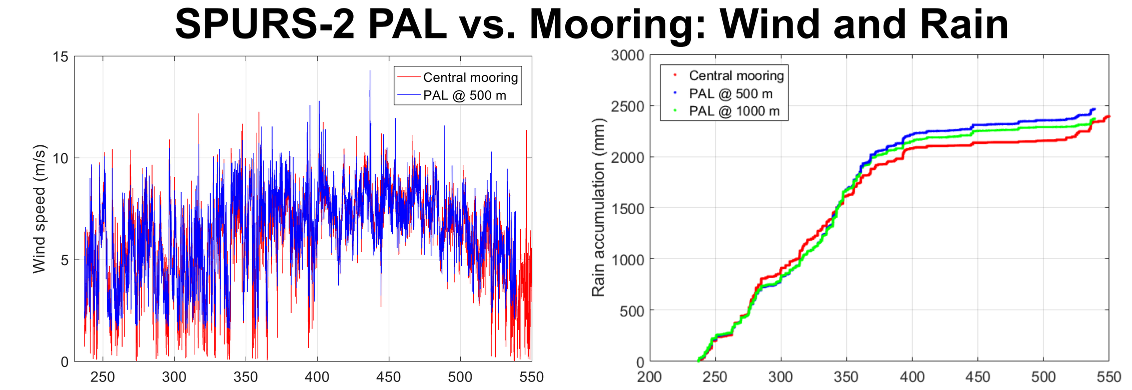


Figure 1 (a) PAL on Argo float and (b) a stand-alone PAL in its own pressure housing. Both types of PAL consist of a broadband, low noise hydrophone (highlighted), a signal processing board, a low-power microprocessor with a 100 kHz A/D digitizer, and a battery pack.

SPURS-2 PAL vs. Mooring vs. IMERG: Rain and Salinity



SPURS-2 PAL vs. Mooring: Wind and Rain



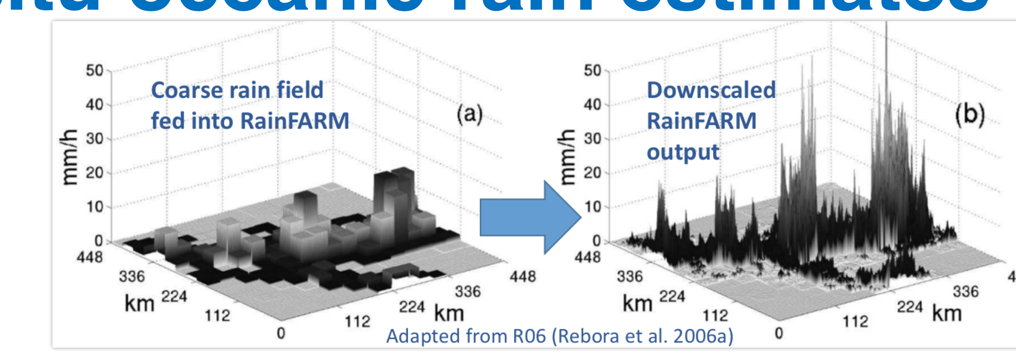
Rain Farm Methods:

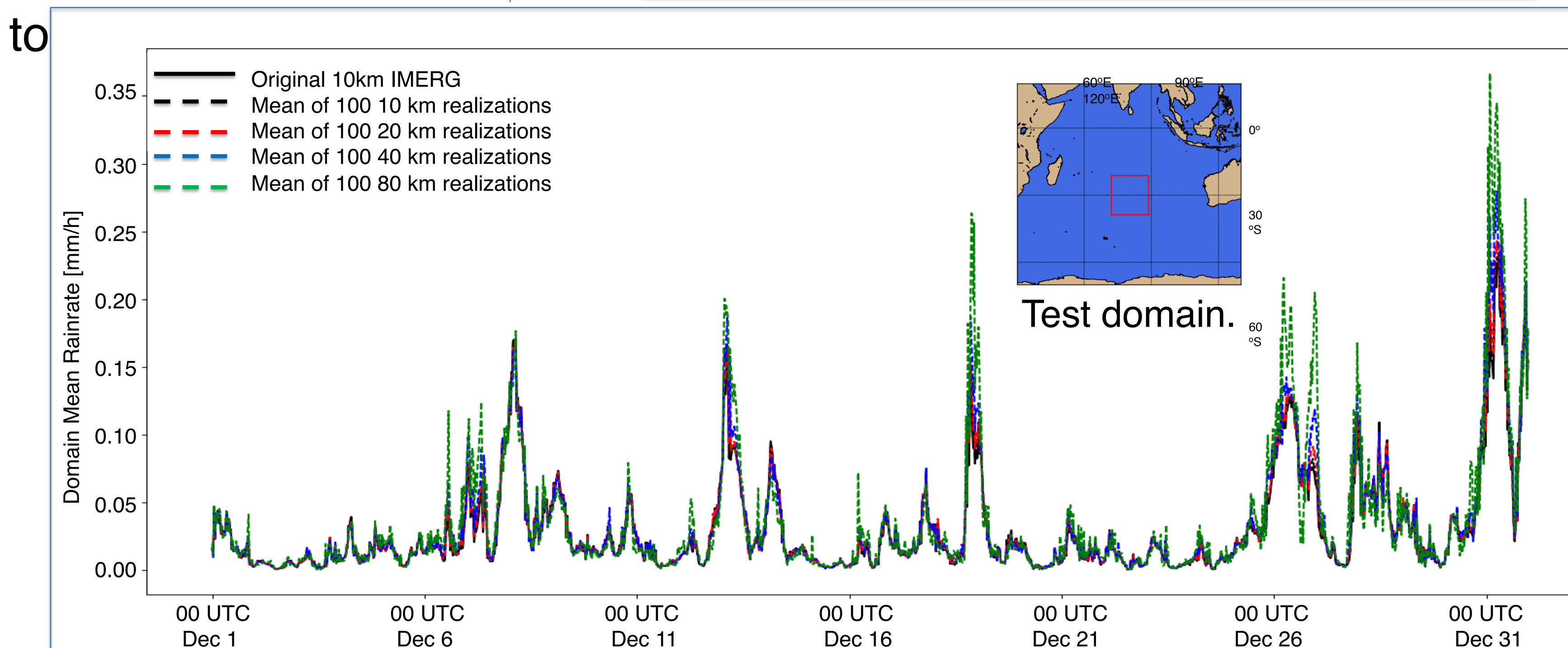
Can RainFARM reproduce statistical characteristics of the original IMERG field?

Following Rebora et al. (2006):

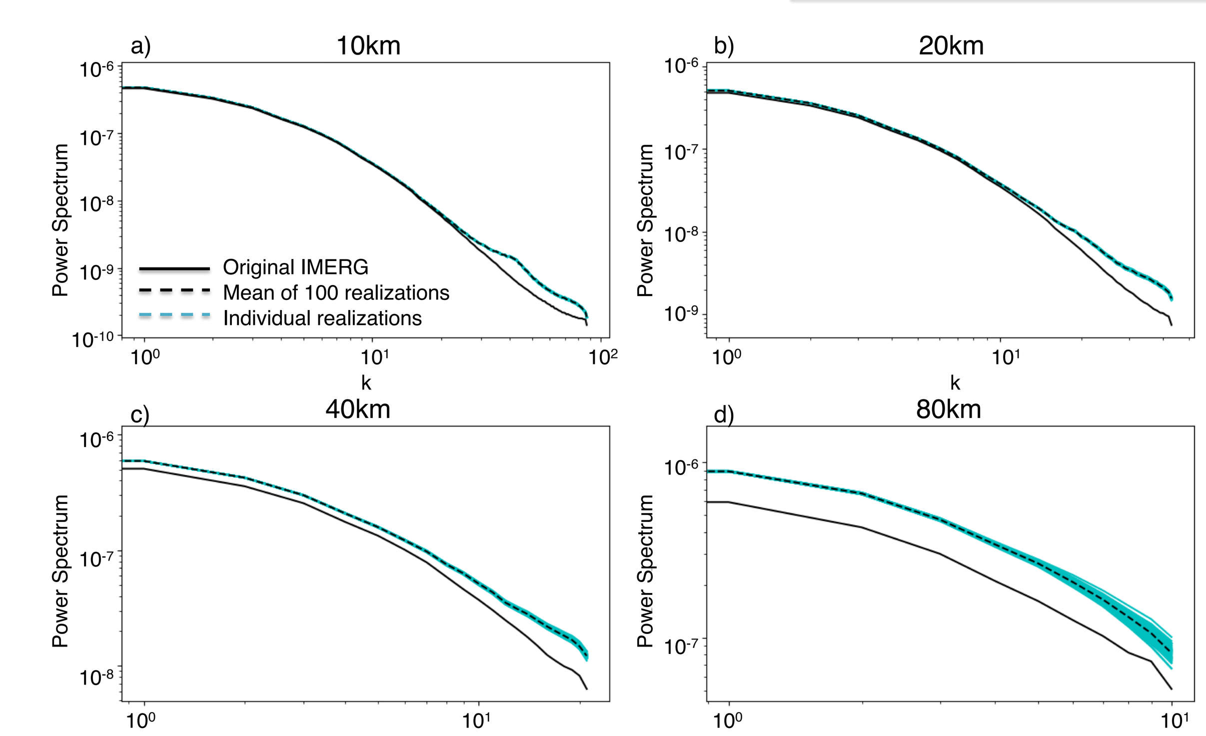
- Average one month (Dec 2017) IMERG to 20, 40, 80, and 160 km resolution over Indian Ocean test domain. Maintain temporal resolution.
- Apply RainFARM to produce 100 realizations of the precipitating field downscaled to 10, 20, 40, and 80 km.
- Compare
  - PDF of 30 minute rain rate (not shown, agreed well)
  - Domain mean 30 min rain rate
  - Power spectra
  - Variance, kurtosis, and skewness of the one-point PDF
  - Number of zeros

Objective 1b: downscale IMERG over locations of in-situ oceanic rain estimates

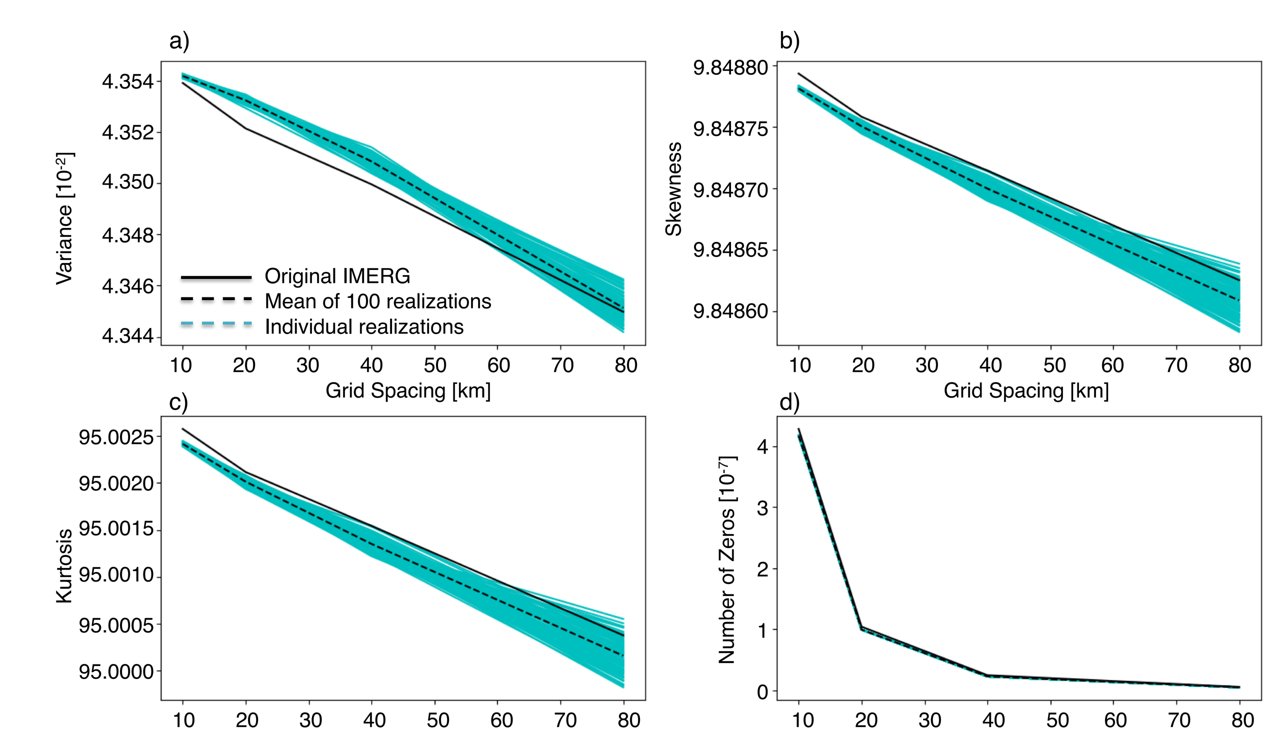




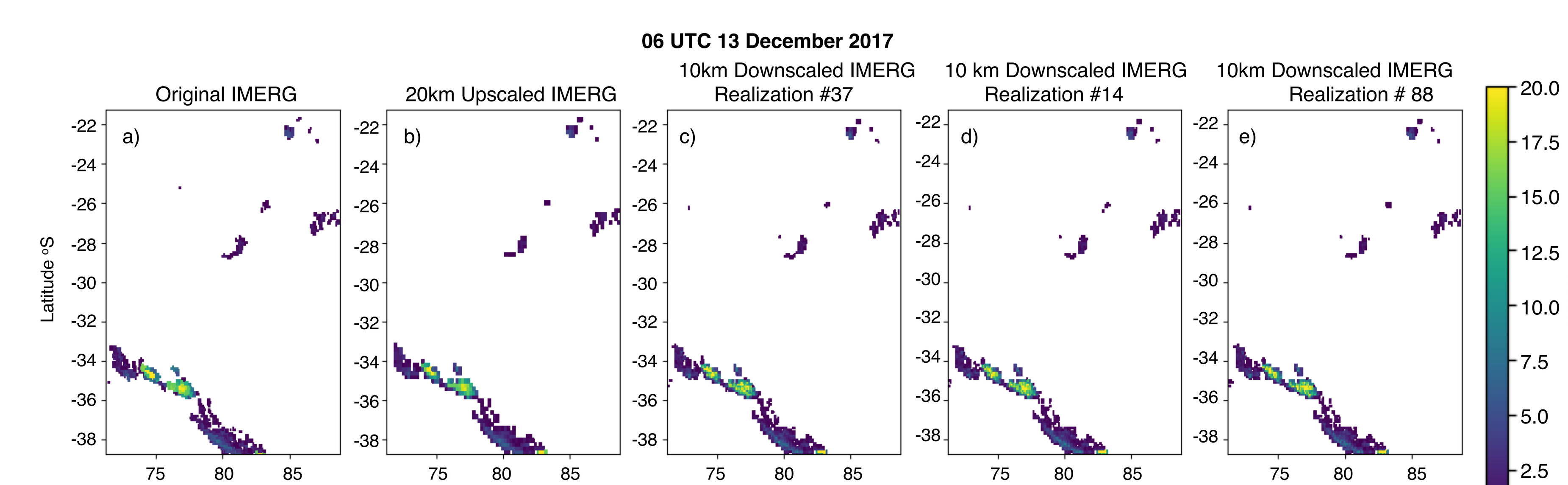
Domain mean rainfall from original IMERG, and the mean of 100 downscaled realizations from RainFARM, 10, 20, 40, and 80 km



Power spectra from original IMERG and 100 downscaled realizations from RainFARM at a) 10km, b) 20km, c) 40km and d) 80km. In b, c, and d, solid lines represent power spectra from averaged (upscaled) IMERG.



a) Variance b) skewness, and c) kurtosis of the one-point PDF and d) number of zeros of original and upscaled IMERG and 100 downscaled realizations from RainFARM at four spatial resolutions



a) Original IMERG at 06 UTC on 13 December 2017;
b) 20-km average of a);
c) d) e) Randomly selected 10km downscaled realizations at the same time from RainFARM

Rebora, N., L.Ferraris, J. von Hardenberg and A. Provenzale, 2006: RainFARM: Rainfall downscaling by a filtered autoregressive model. *J. Hydromet.* **7**, 724-738, https://doi.org/10.1175/JHM517.1